Claims

We claim:

[c1]   A method for determining a characteristic of a mud mixture surrounding a drilling tool within an inclined borehole in which a drilling tool is conveyed, comprising:

defining a cross-section of said tool which is orthogonal to a longitudinal axis of said tool;

determining a bottom contact point of said cross-section of said tool which contacts said inclined borehole as said tool rotates in said borehole;

separating said cross-section into at least two segments, where one of said segments is called a bottom segment of said borehole which includes said bottom contact point of said cross-section of said tool with said inclined borehole;

turning said tool in said borehole;

applying energy into said borehole from an energy source disposed in said tool, as said tool is turning in said borehole;

recording measurement signals received at a sensor disposed in said tool from circumferentially spaced locations around said borehole, where said measurement signals are in response to returning energy which results from the interaction of the applied energy with said mud mixture and the formation;

associating said measurement signals with a particular segment during the time such signals are produced in response to energy returning from said mud mixture and the formation as said tool is turning in said borehole;

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deriving an indication of a characteristic of said mud mixture as a function of said measurement signals associated with a plurality of said at least two segments of said borehole; and

comparing said indications of a characteristic of said mud mixture for said plurality of segments with at least one of each other and a known indication of a characteristic of said mud mixture.

[c2]   The method of claim 1, wherein an indication of a characteristic of said mud mixture is derived for at least three of said segments.

[c3]   The method of claim 1, wherein an indication of a characteristic of said mud mixture is derived for each of said segments.

[c4]   The method of claim 1 wherein said energy applied into said borehole is in the form of gamma rays radiated from a source of radiation, and said returning energy is in the form of gamma rays which result from interaction with said mud mixture and the formation.

[c5]   The method of claim 1 wherein said energy applied into said borehole is in the form of neutrons radiated from a source of radiation, and said returning energy is in the form of radiation which results from interaction of said neutrons with said mud mixture and the formation.

[c6]   The method of claim 1 wherein said energy applied into said borehole is in the form of ultrasonic pulses, and said returning energy is in the form of ultrasonic pulses which interact with said mud mixture.

[c7]   The method of claim 1 wherein said cross-section is divided into bottom, right, top, and left segments.

[c8]   The method of claim 7 wherein said energy applied into said borehole is in the form of gamma rays, and said returning energy is in the form of gamma rays which result from interaction with said mud mixture and the formation, the method further comprising, recording the identity of a segment that said sensor is in while said tool is turning in said borehole, and recording the number of gamma ray counts of said sensor per segment for a selected recording time.

[c9]   The method of claim 8 wherein said sensor comprises short and long spaced gamma ray detectors spaced from an energy source which emits gamma rays into said mud mixture and the formation, and further comprising, recording the number of gamma ray counts of said short spaced gamma ray detector per segment for a certain recording time, and recording the number of gamma ray counts of said long spaced gamma ray detector per segment for said certain recording time.

[c10]   A method for determining density of a mud mixture surrounding a drilling tool within an inclined borehole in which said drilling tool is received, comprising:

        determining a bottom contact point of said tool which contacts said inclined borehole while said tool is rotating in said borehole defining a bottom angular distance of said borehole for said tool which includes said bottom contact point;

        defining at least one more angular distance of said borehole;

        applying gamma rays into said mud mixture from a radiation source;

        recording, as a function of angular distance of said tool with respect to the borehole for a predetermined time period, a count rate of gamma rays which return to the tool which result from interaction with said mud mixture;

determining a density of the mud mixture from the count rate of gamma rays for at least two segments of said borehole; and

comparing said densities of said mud mixture for said at least two segments with at least one of each other and a known density of said mud mixture.

[c11] The method of claim 10 further comprising, defining other angular distances of said tool about said borehole, and determining the density of the mud mixture for a plurality of said angular distances from the gamma ray count rates which occur solely within said angular distances about said borehole.

[c12] The method of claim 11 further comprising, determining the density of the mud mixture for each of said angular distances from the gamma ray count rates which occur solely within said angular distances about said borehole.

[c13] The method of claim 10 wherein said gamma ray count rates are recorded as to their respective energy levels, called windows, thereby producing a spectrum of count rates with certain higher energy level windows being designated as hard windows and with certain lower energy level windows being designated as soft windows.

[c14] The method of claim 13 wherein for each distinct angular distance about said borehole, count rates of hard windows which occur solely within a distinct angular distance are used to determine density of the mud mixture.

[c15] A method for determining photoelectric effect (PEF) of a mud mixture within a borehole in which a tool is received, said tool including a source of radiation, a short spaced gamma ray detector and a long spaced gamma ray detector, the method comprising:

identifying particular angular segments of said borehole through which said short spaced detector and said long spaced detector pass while said tool is rotating in said borehole;

recording for a predetermined time period a count rate of gamma rays in said short spaced detector and in said long spaced detector as a function of said particular angular segments, where said gamma rays result from interaction of gamma rays from said source with said mud mixture, and where said count rate of gamma rays of said short spaced detector and of said long spaced detector are recorded as to their respective energy levels called windows, thereby producing a spectrum of count rates with certain higher energy level windows being designated as hard windows and with certain lower energy level windows being designated as soft windows;

determining average density (ρ_{AVG}), of the mud mixture; and

determining a macroscopic cross section, called U_{AVG}, of the mud mixture as a function of total soft window count rate of one of said detectors and total hard window count rate of said one of said detectors, and

determining an average PEF of said formation as a ratio of said macroscopic cross section to said average density, that is,

$$PEF_{AVG} = U_{AVG} / \rho_{AVG} .$$

[c16] The method of claim 15 wherein said average density (ρ_{AVG}) of said mud mixture is determined from the steps of determining a total hard window count rate from said short spaced detector, determining a total hard window count rate from said long spaced detector, and applying said short spaced detector hard window count rate and said long spaced detector hard window count rate to a spine and ribs

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representation of the response of a two-detector density device to formation density and drilling mud and mudcake.

[c17] The method of claim 15 further comprising:

determining average density of a particular angular segment ($\rho_{\text{AVG SEGMENT}}$);

determining a macroscopic cross section of said particular angular segment ($U_{\text{AVG SEGMENT}}$) as a function of soft window count rate of said one of said detectors for said particular angular segment and hard window count rate of said one of said detectors for said particular angular segment; and

determining an average PEF of said particular angular segment as a ratio of said $U_{\text{AVG SEGMENT}}$ to said $\rho_{\text{AVG SEGMENT}}$, that is,

$$PEF_{\text{AVG SEGMENT}} = U_{\text{AVG SEGMENT}} / \rho_{\text{AVG SEGMENT}}.$$

[c18] The method of claim 1, further comprising comparing said measurement signals from a plurality of segments to detect cuttings bed buildup.

[c19] The method of claim 1, further comprising comparing said measurement signals from a plurality of segments to detect a kick.

[c20] The method of claim 11, further comprising comparing said density measurements from a plurality of angular distances to detect cuttings bed buildup.

[c21] The method of claim 11, further comprising comparing said density measurements from a plurality of angular distances to detect a kick.

[c22] The method of claim 15, further comprising comparing said PEF measurements from a plurality of angular segments to detect cuttings bed buildup.

[c23] The method of claim 15, further comprising comparing said PEF measurements from a plurality of angular segments to detect a kick.